Surface Assessment and Modelling of Behaviour

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Assessment requirements…

- Athlete interaction with surfaces
- Ball interaction with surfaces
- The challenge…
  - Produce affordable surfaces with good, consistent performance for athletes (comfort, safety and play) and ball interaction (play)

Mechanical behaviour – Loading due to Athlete…

- Cushioning or Force-reduction
  - Berlin Athlete and others
- Sliding friction
  - Pendulum devices, sledges
- Traction
  - Rotary devices, sledges

Measuring Traction on Turf

- *Players seek sufficient traction for* performance
  - carry out specific movements

- Injury risk *should be minimised*
  - reduce high traction forces and moments

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Artificial Turf in Football Today

- *Governing bodies allow use at professional level*
  - World Cup 2006 qualifiers
  - UEFA games from 2005-6 season
- *High use at amateur level*
  - Less maintenance (?)
  - Consistency

Need for physical insight into characteristics of artificial pitches

Traction Tester

Turf sample

Traction Tester

Studs attached to sled in desired orientation

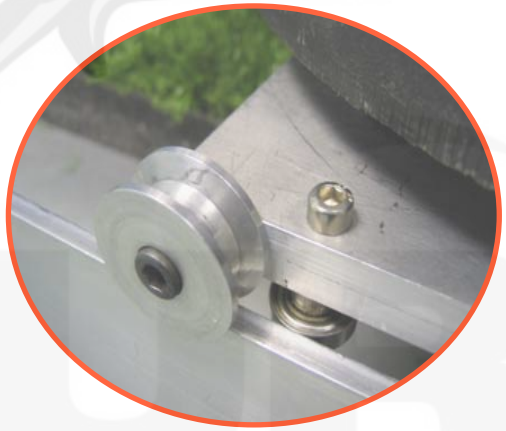
5 stud pattern used

Traction Tester

Penetration level set on screw gauge

Traction Tester

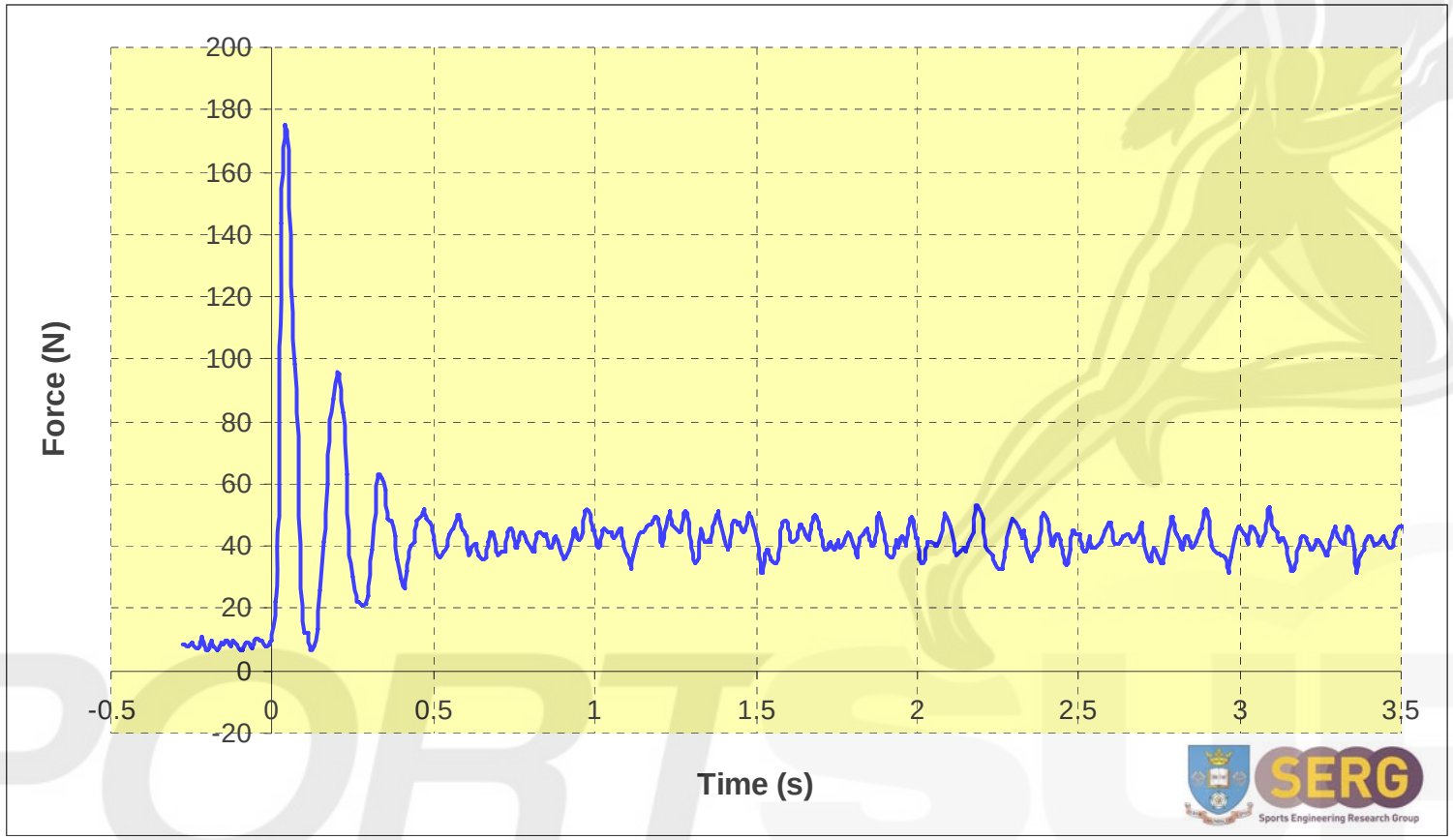
Low friction rollers maintain penetration level



Traction Tester

Sled pulled by constant speed motor (up to 0.4 m/s)

Traction Measurement



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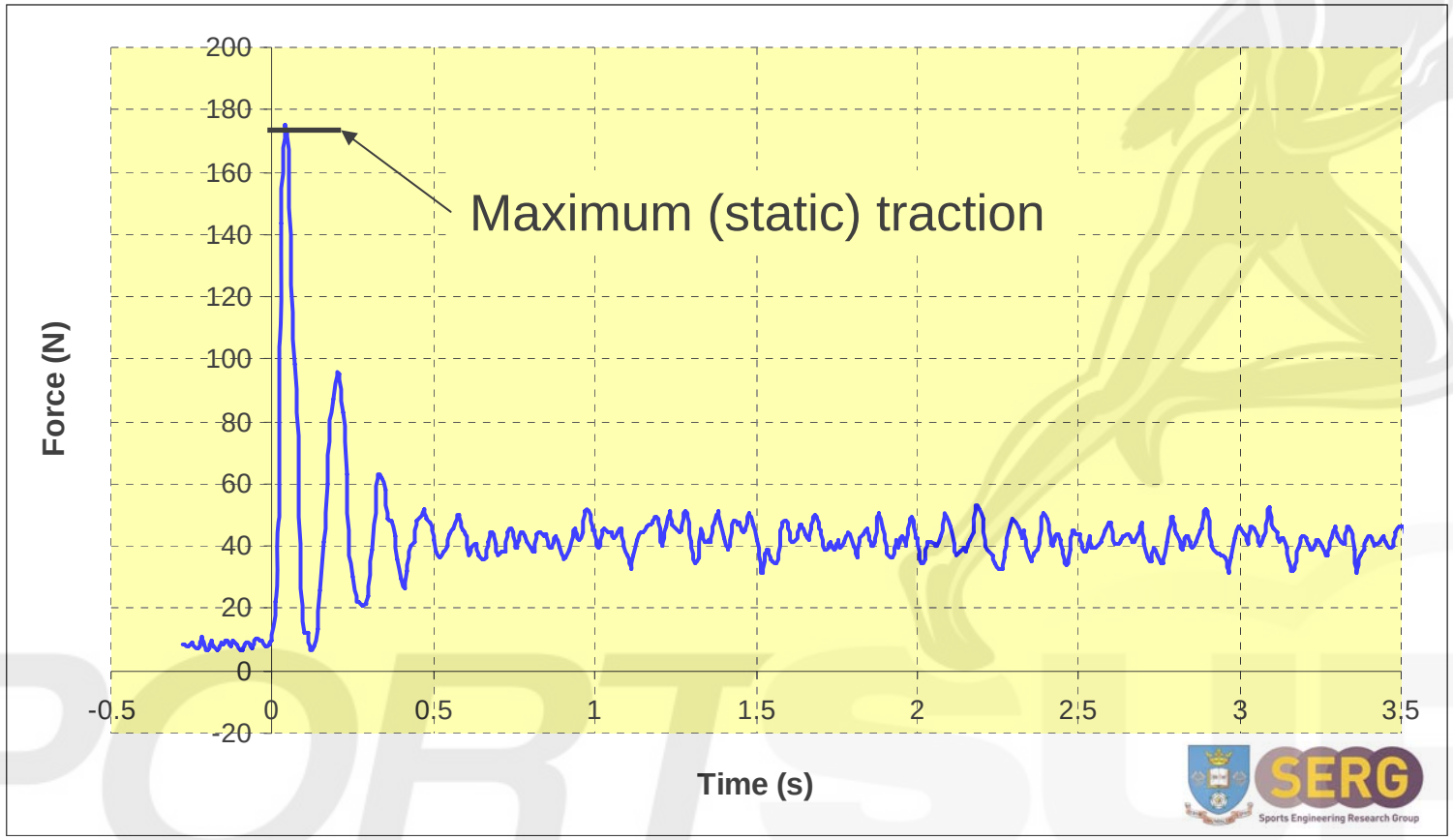
Traction Measurement



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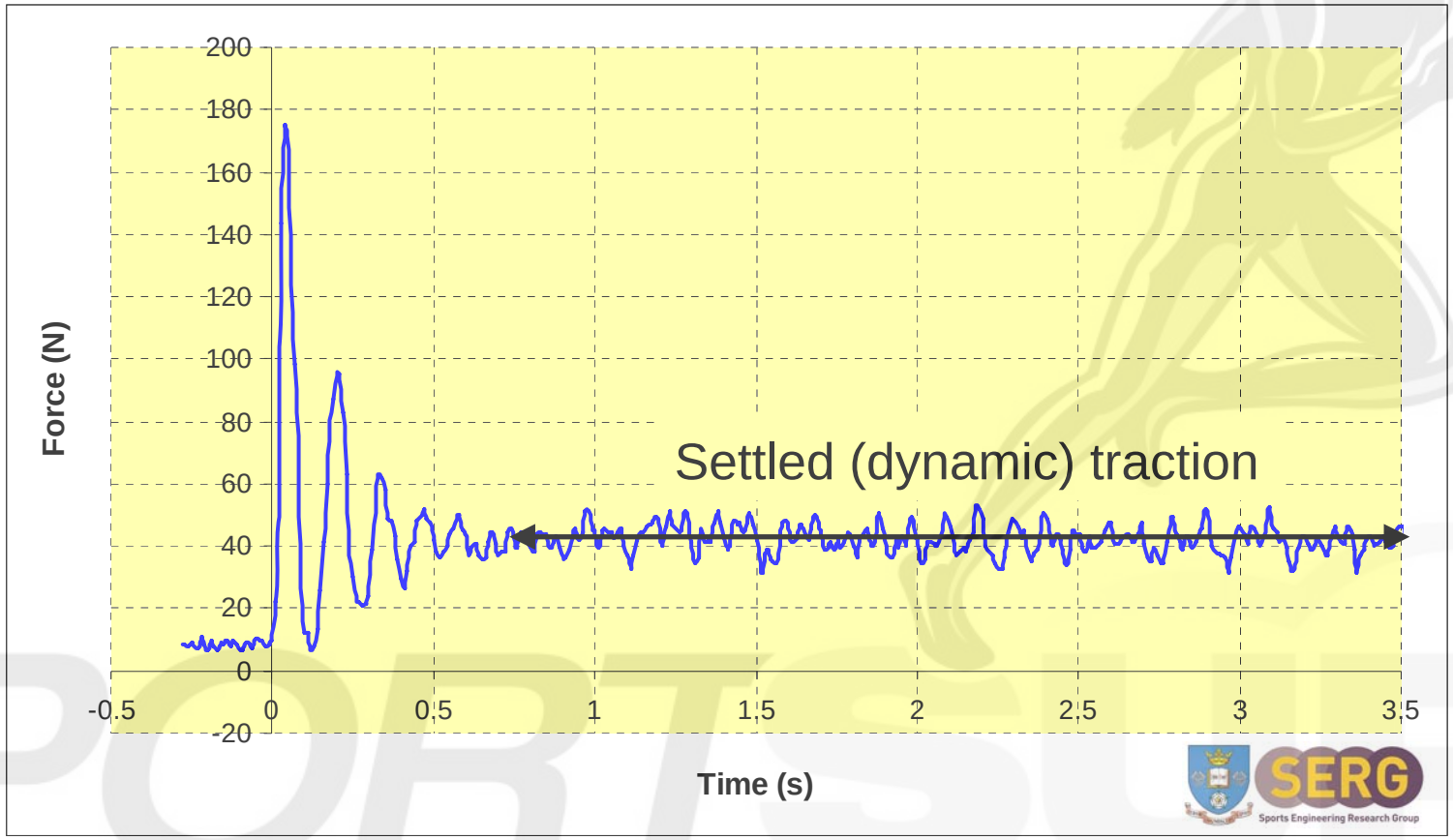
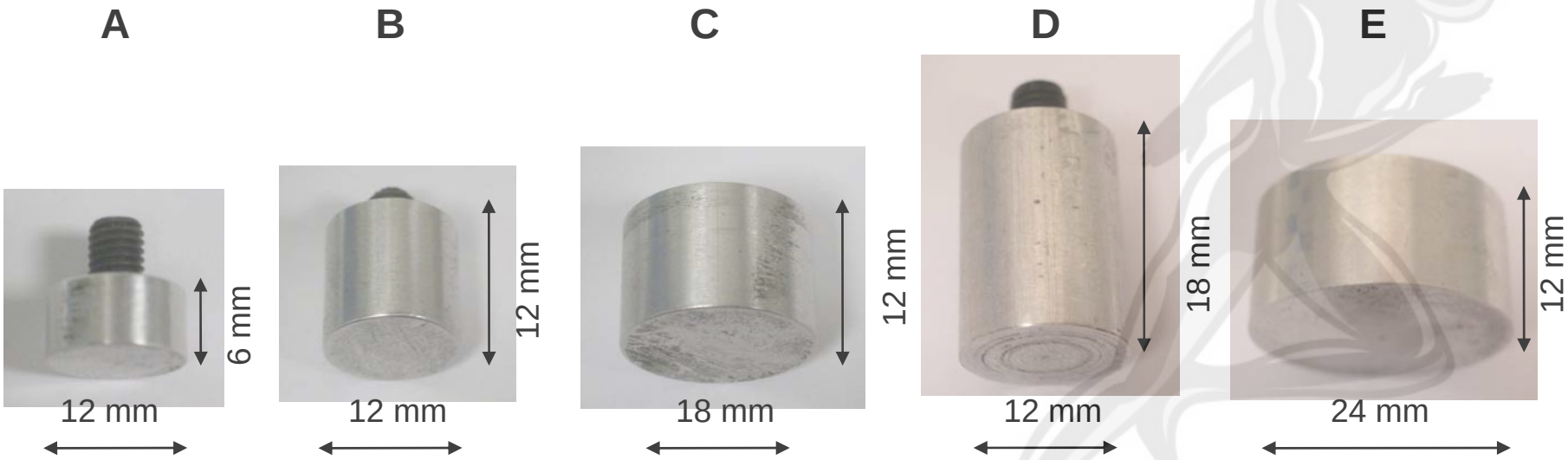
Traction Measurement

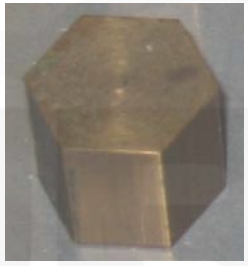


Studs Tested



- Circular studs
  - Various sizes
- Other shapes
- Mixed configurations

Cuboid



Hexagonal

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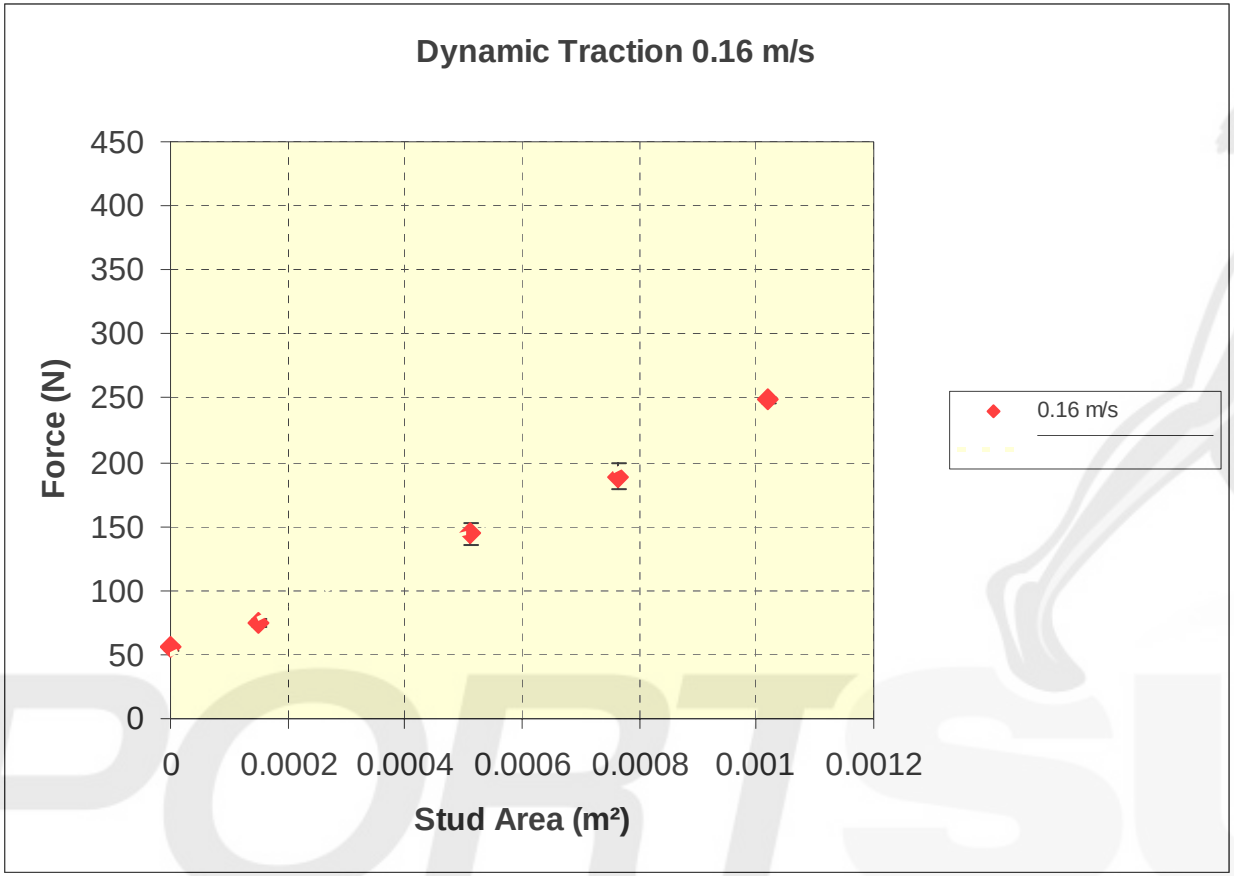
Dependence on Area



- *Mean values with standard error bars for studs A to D*

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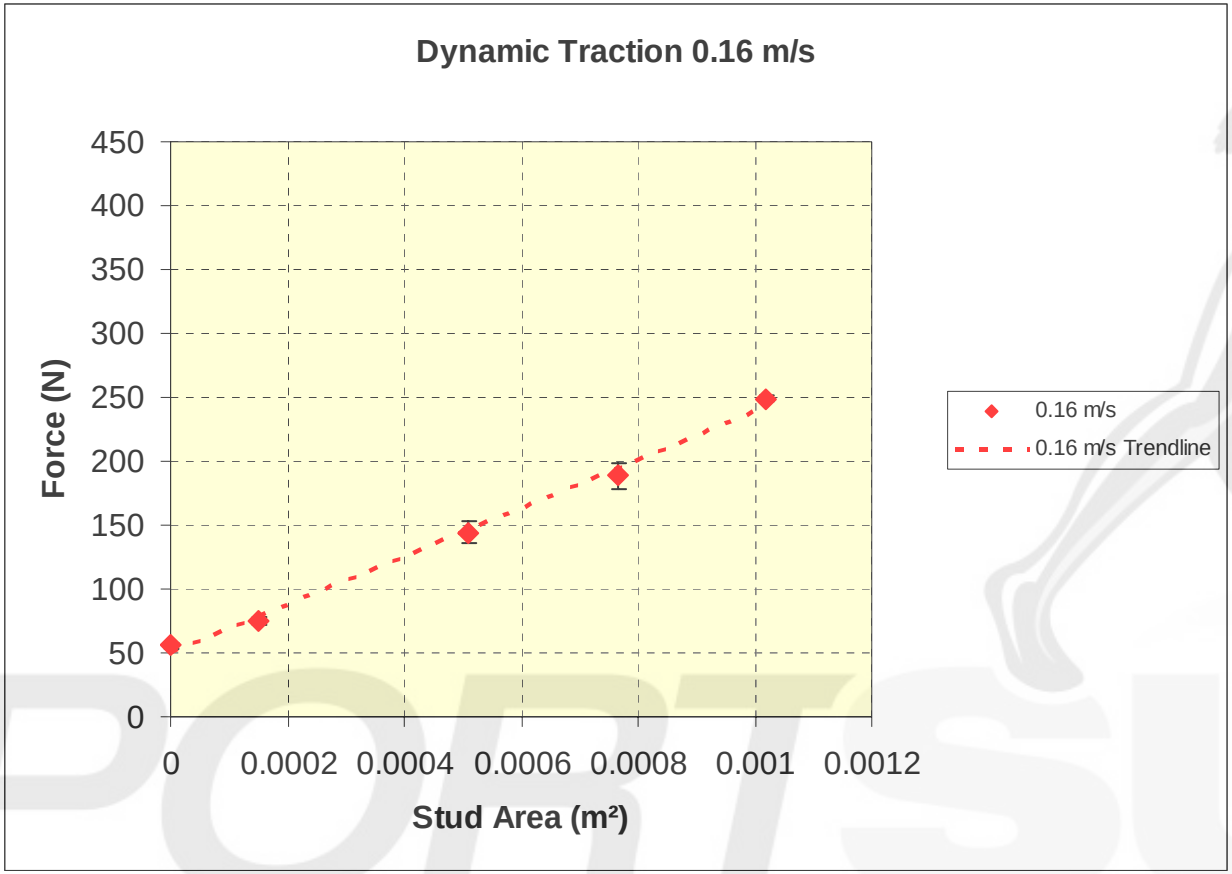
Dependence on Area



- *Mean values with standard error bars for studs A to D*
- *Trend line*

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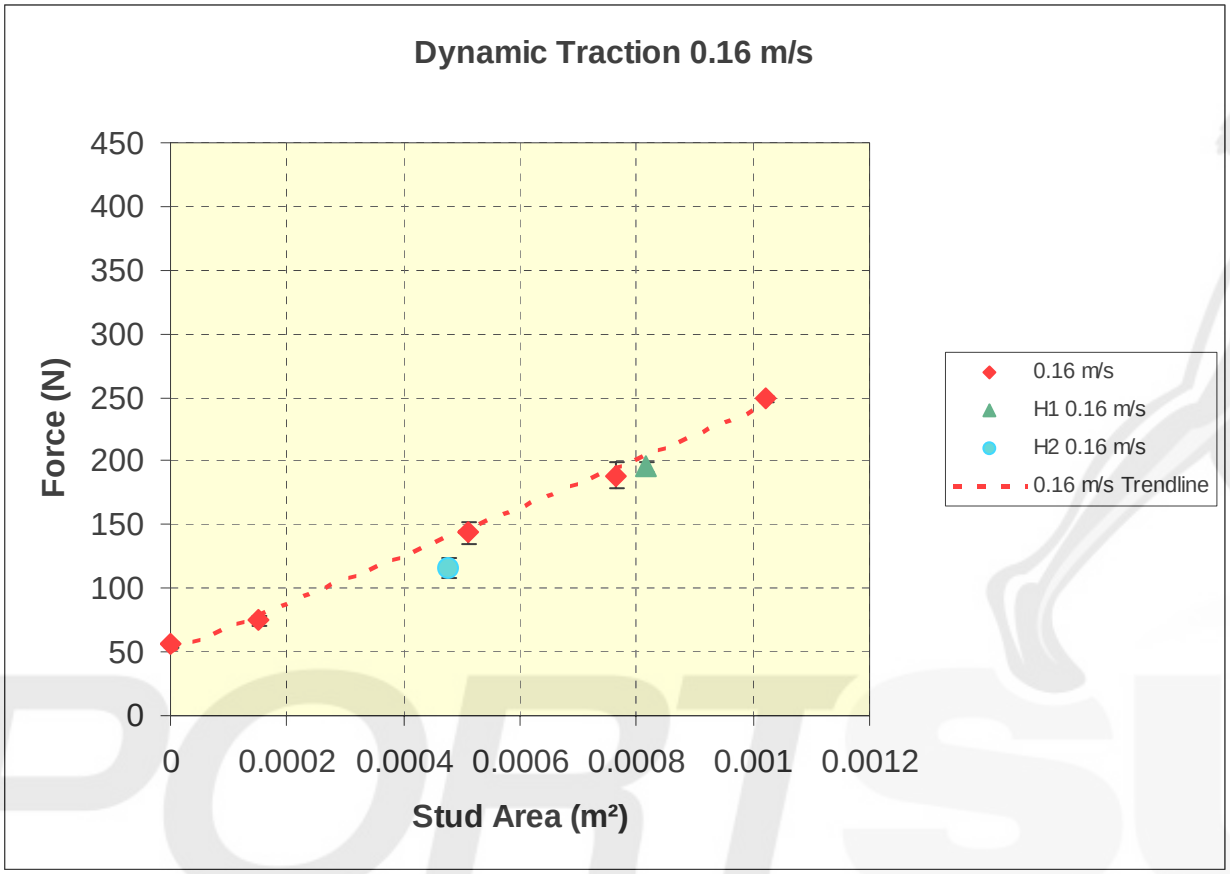
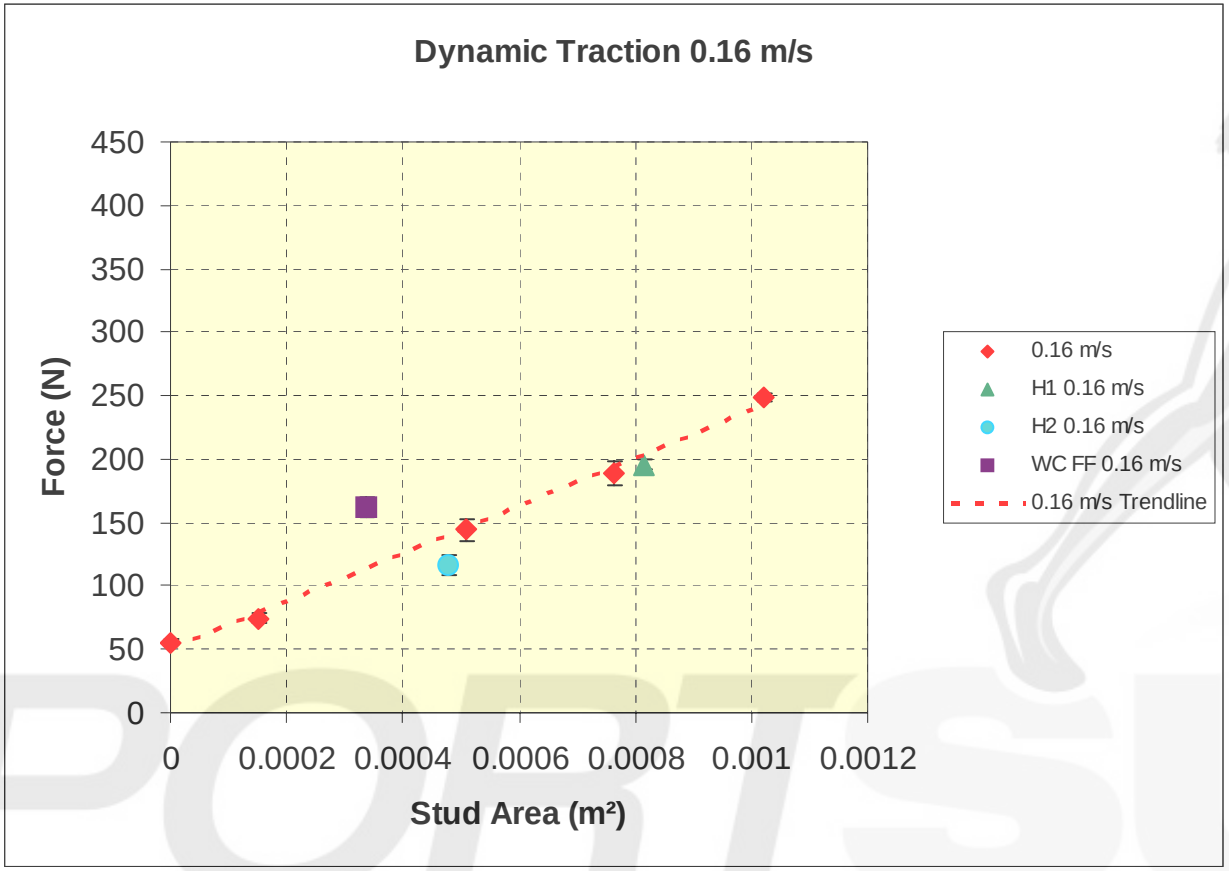
Dependence on Area



- *Mean values with standard error bars for studs A to D*
- *Trend line*
- *Hybrid configurations*

Dependence on Area



- *Mean values with standard error bars for studs A to D*
- *Trend line*
- *Hybrid configurations*
- *World Cup FF (adidas)*

Turf Traction Summary

- *Traction is less dependent on velocity, compared to stud cross-sectional area and geometry*

- *Model to be developed further to include more stud and surface parameters*

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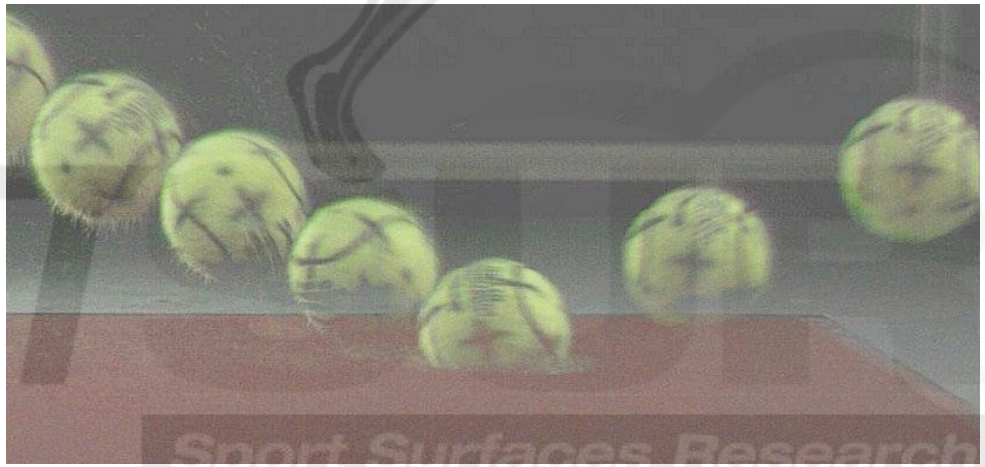
Mechanical behaviour – Loading due to ball…

- Ball impacts
  - E.g. tennis, cricket, football
  - Restitution, energy return
  - Sliding, rolling friction
  - Deformation
- Rolling
  - E.g. hockey, football



Types of impact

- Deformable ball / rigid surface
  - e.g. tennis
- Rigid ball / deformable surface
  - e.g. golf
- Deformable ball / deformable surface
  - e.g. cricket

Measuring Impacts…

- Photogrammetry
  - High speed video
  - Strobe photography
- Simulated impacts
  - Light gate systems

Measuring Restitution…

- Ball drops
  - Standard approach
- Impact hammers
  - Generate surface behaviour data

- Design incorporating accelerometer
- Mounted on linear rail

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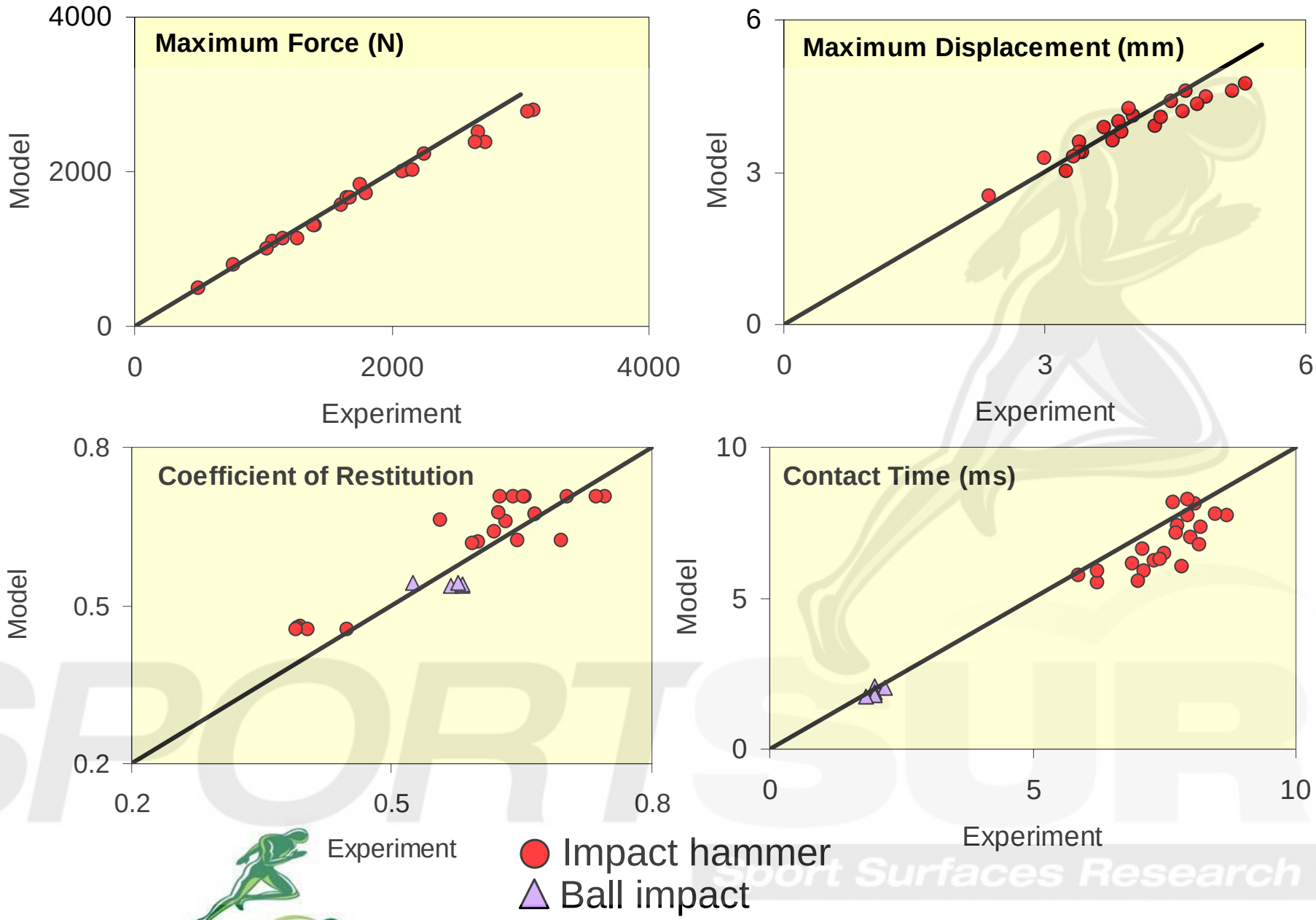

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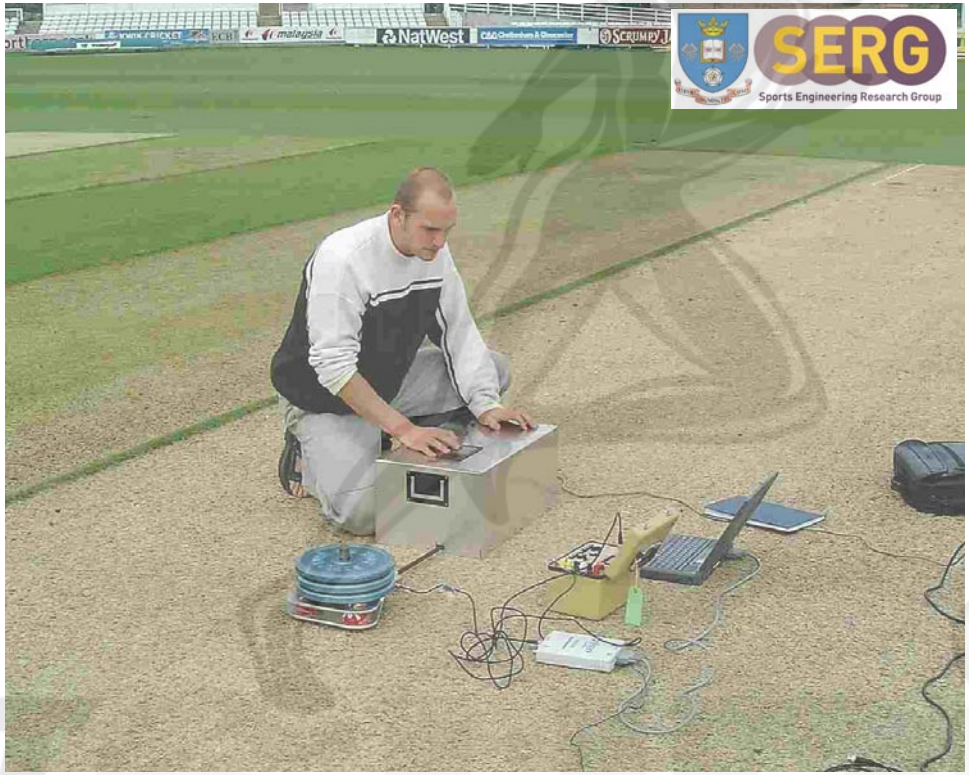
Measuring Friction…

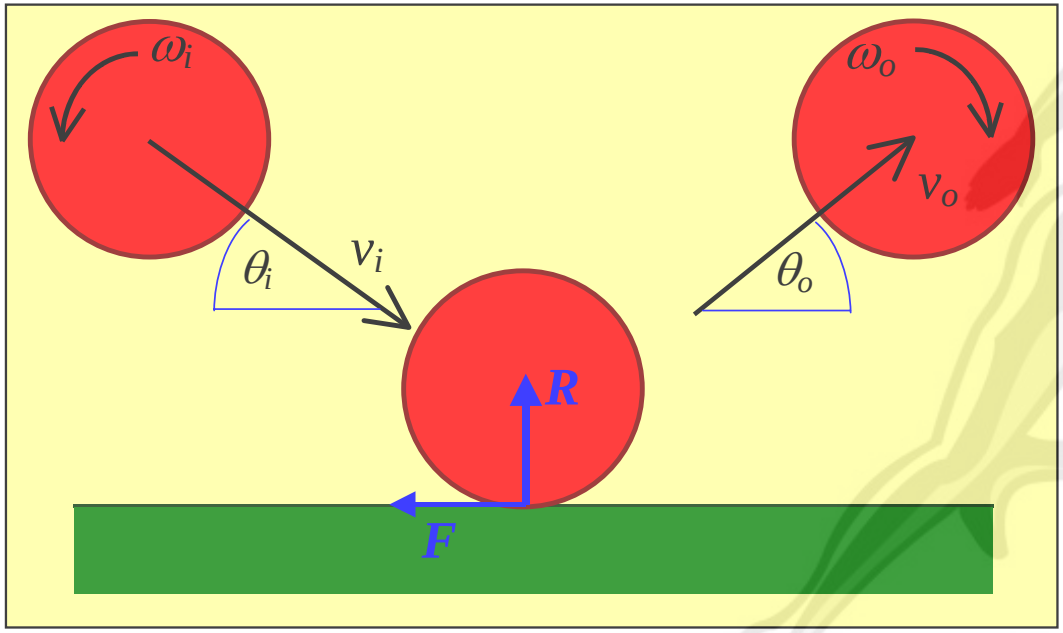
- Pendulums
- Sledges



Modelling Ball Impact Behaviour…

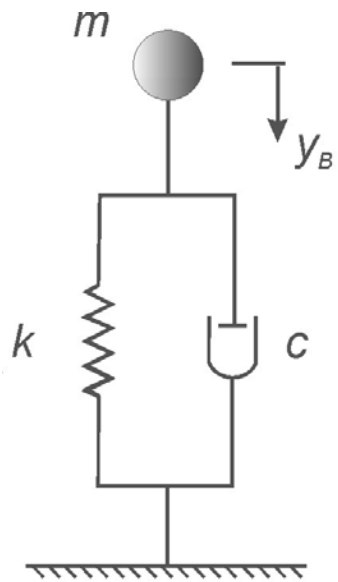
- Newtonian models
  - Simple, can be effective
- Spring-damper models
  - Describe behaviour of ball and surface
- FE models
  - *Potential* to simulate all behaviour for some cases

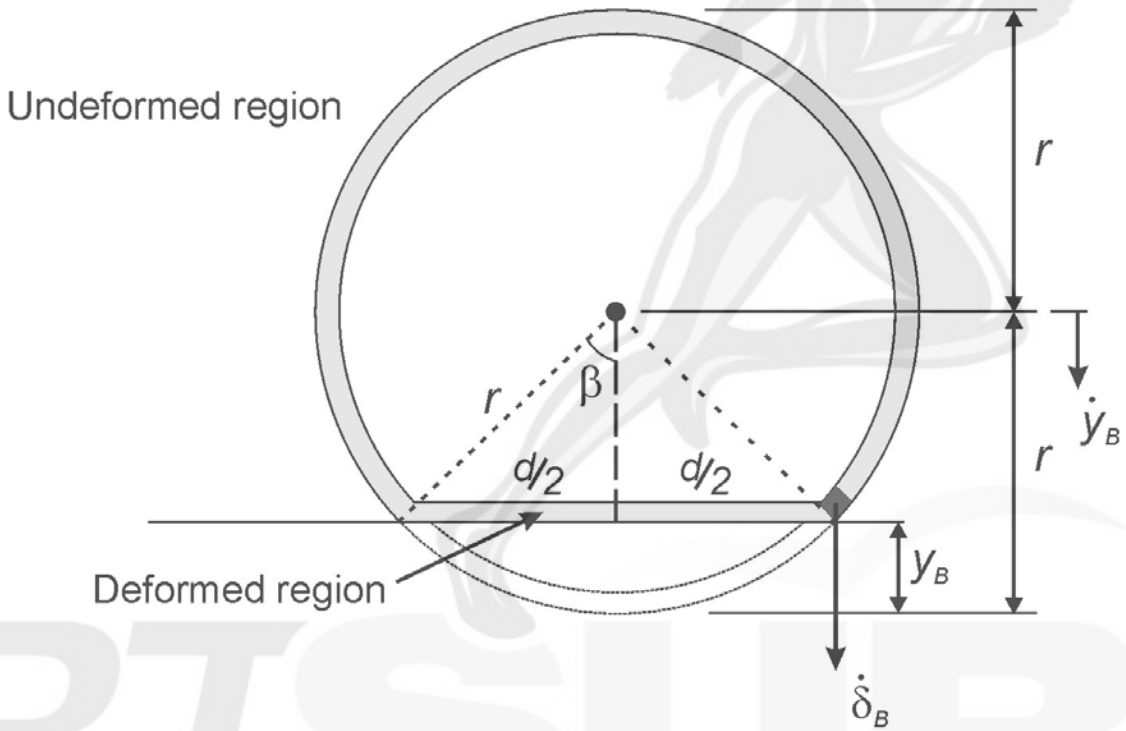
Newtonian models…



- Used effectively in cricket
  - Combined ball drop and friction info
  - Predicted pace of pitches

Modelling Tennis ball Impact…





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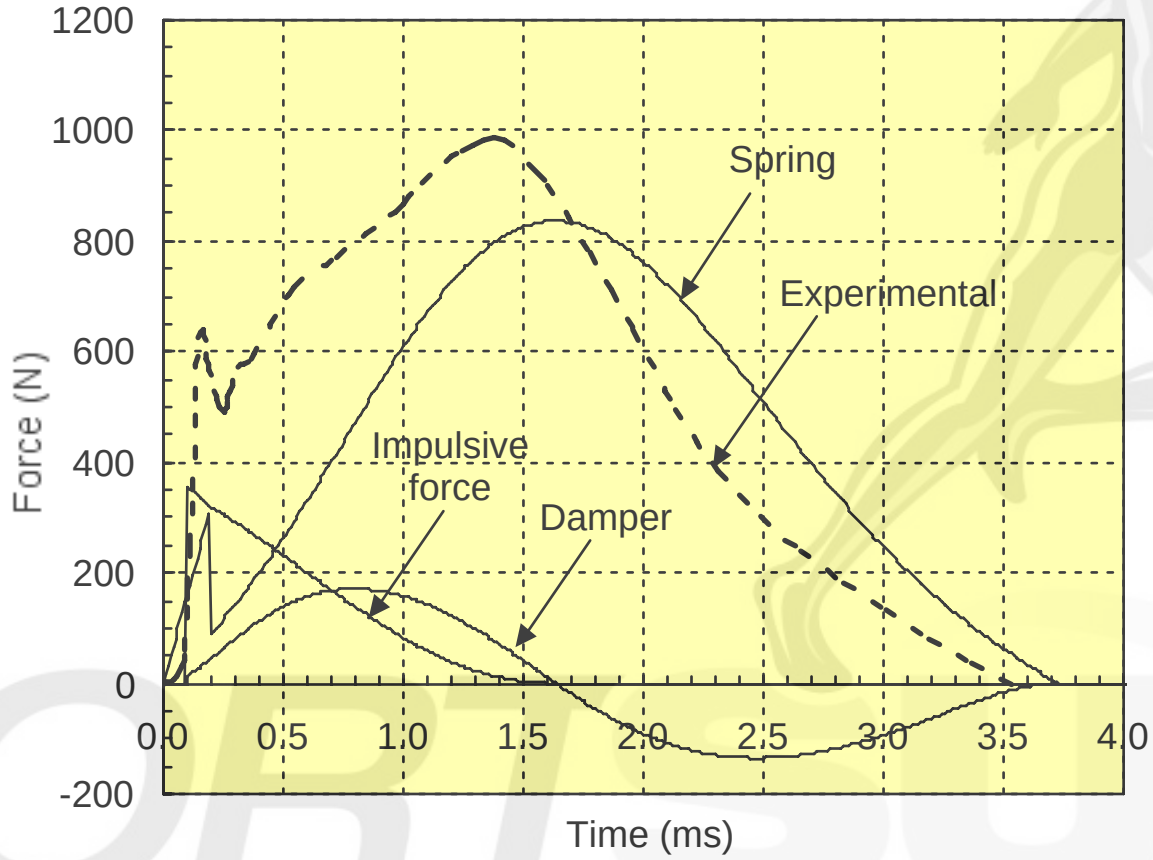
Forces during normal impact



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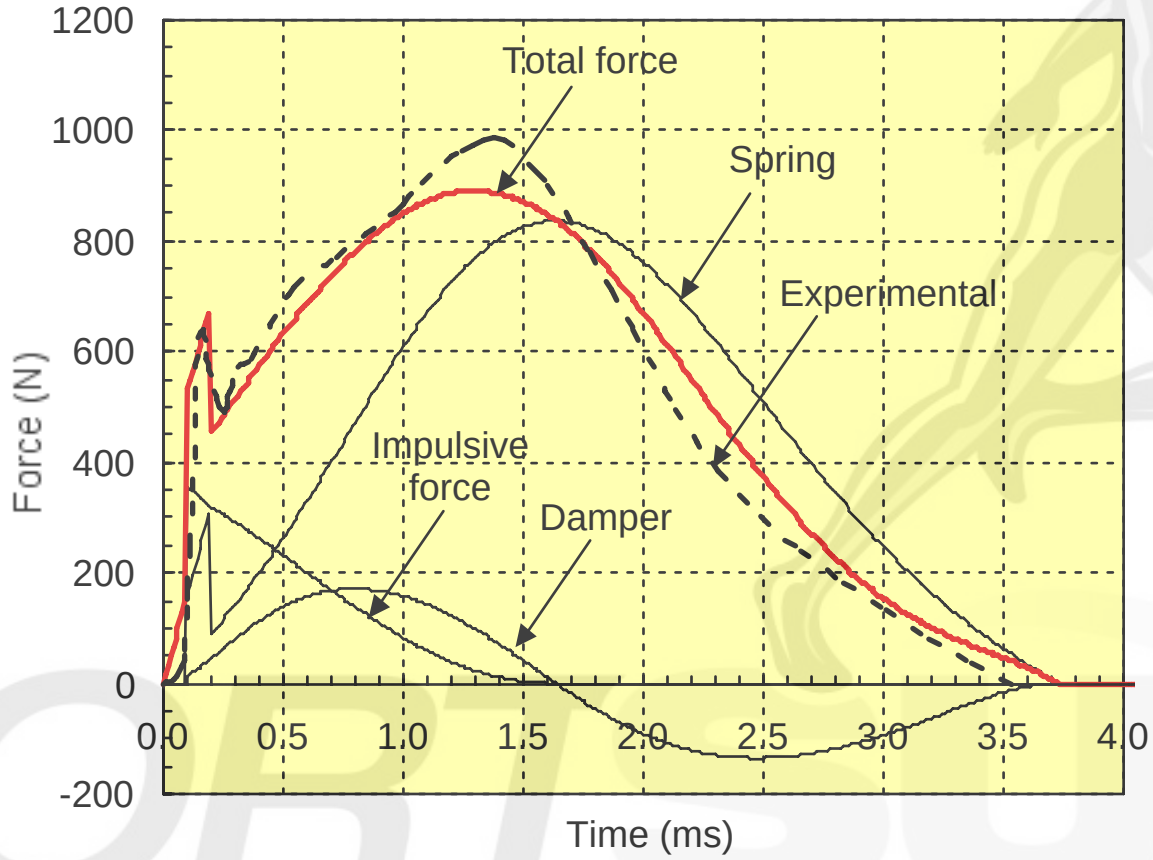
Forces during normal impact



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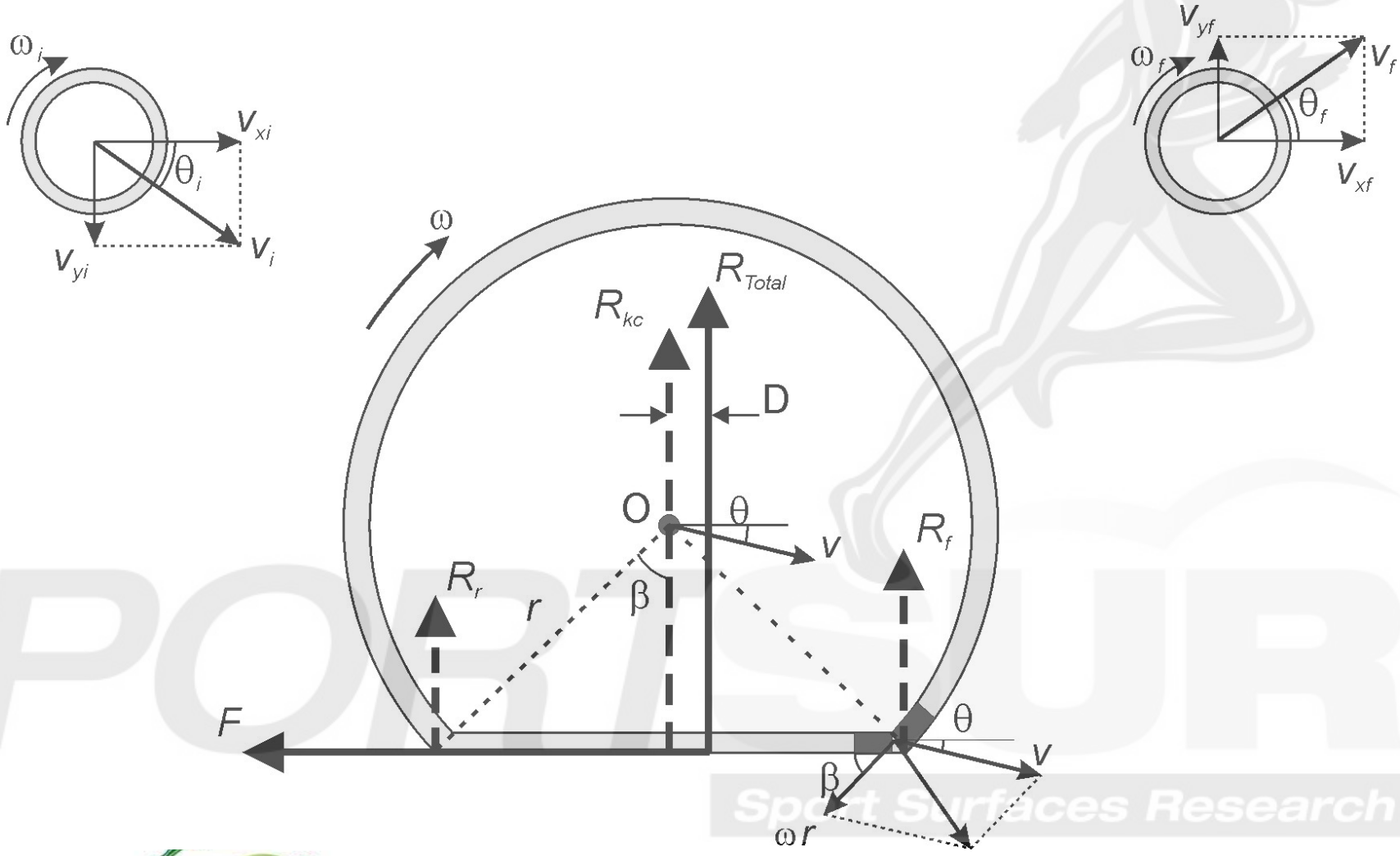
Forces during oblique impact



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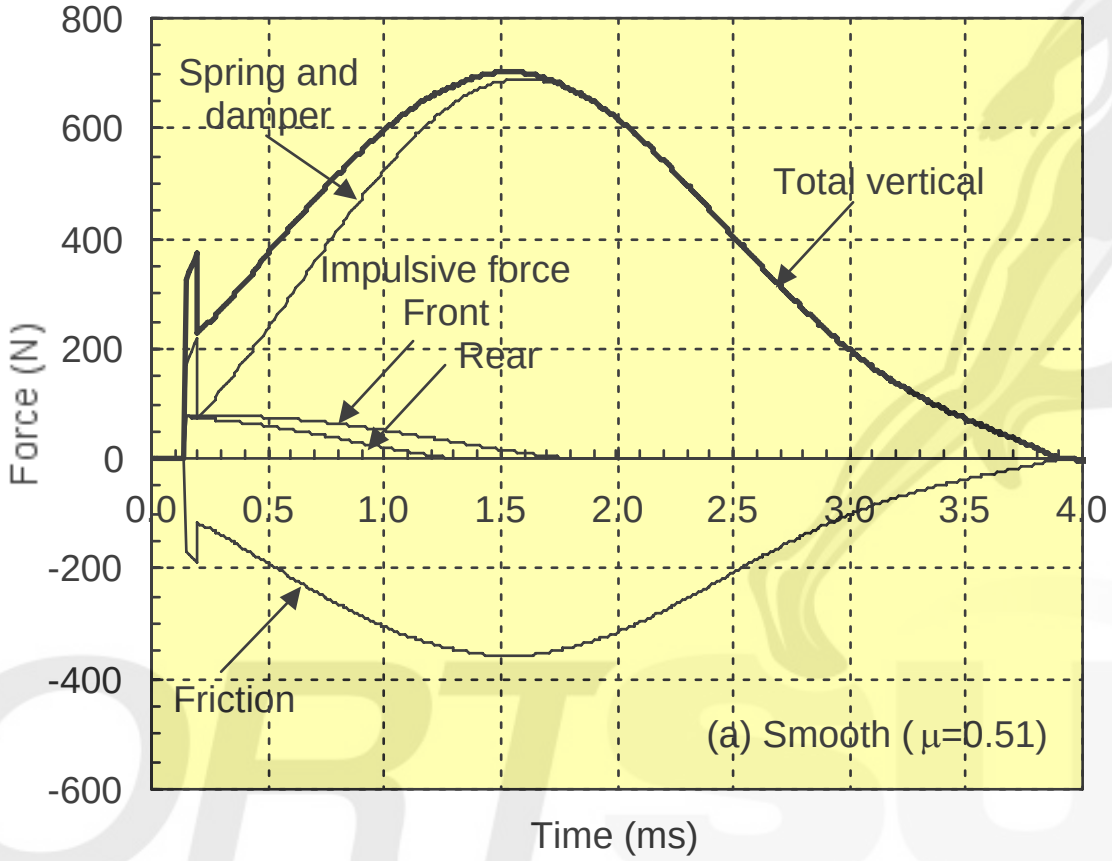
Forces during oblique impact



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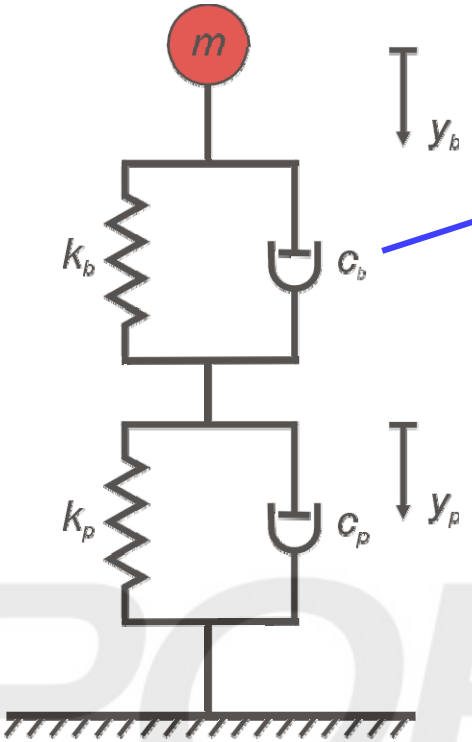
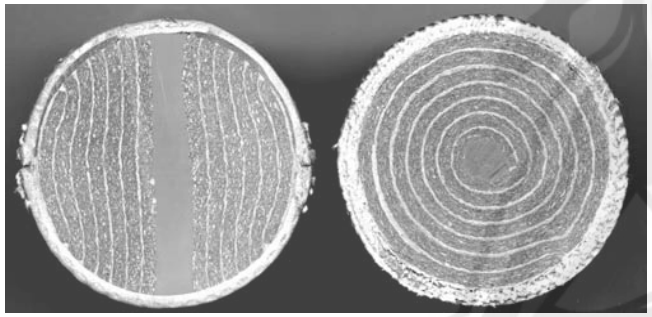
Result of Tennis Study…

TennisGUT

3dcourt.exe

Modelling Cricket Ball Impact…



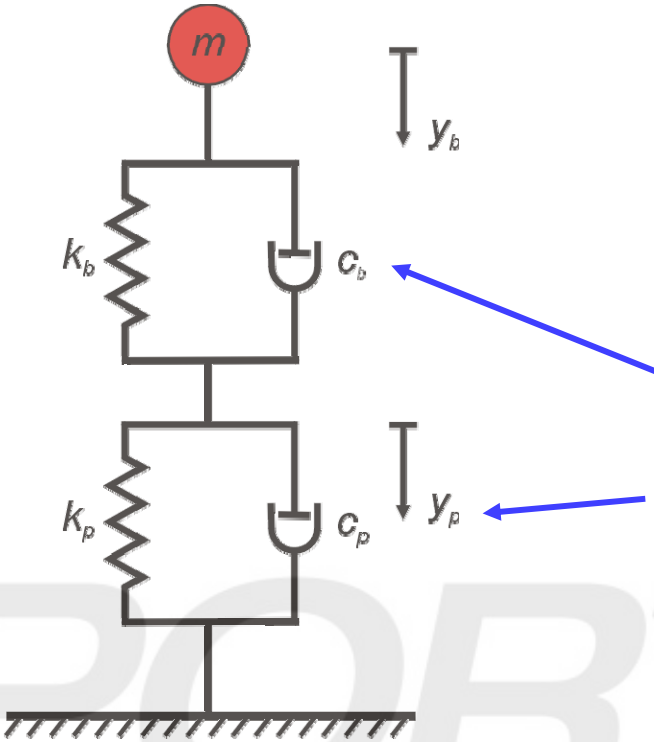


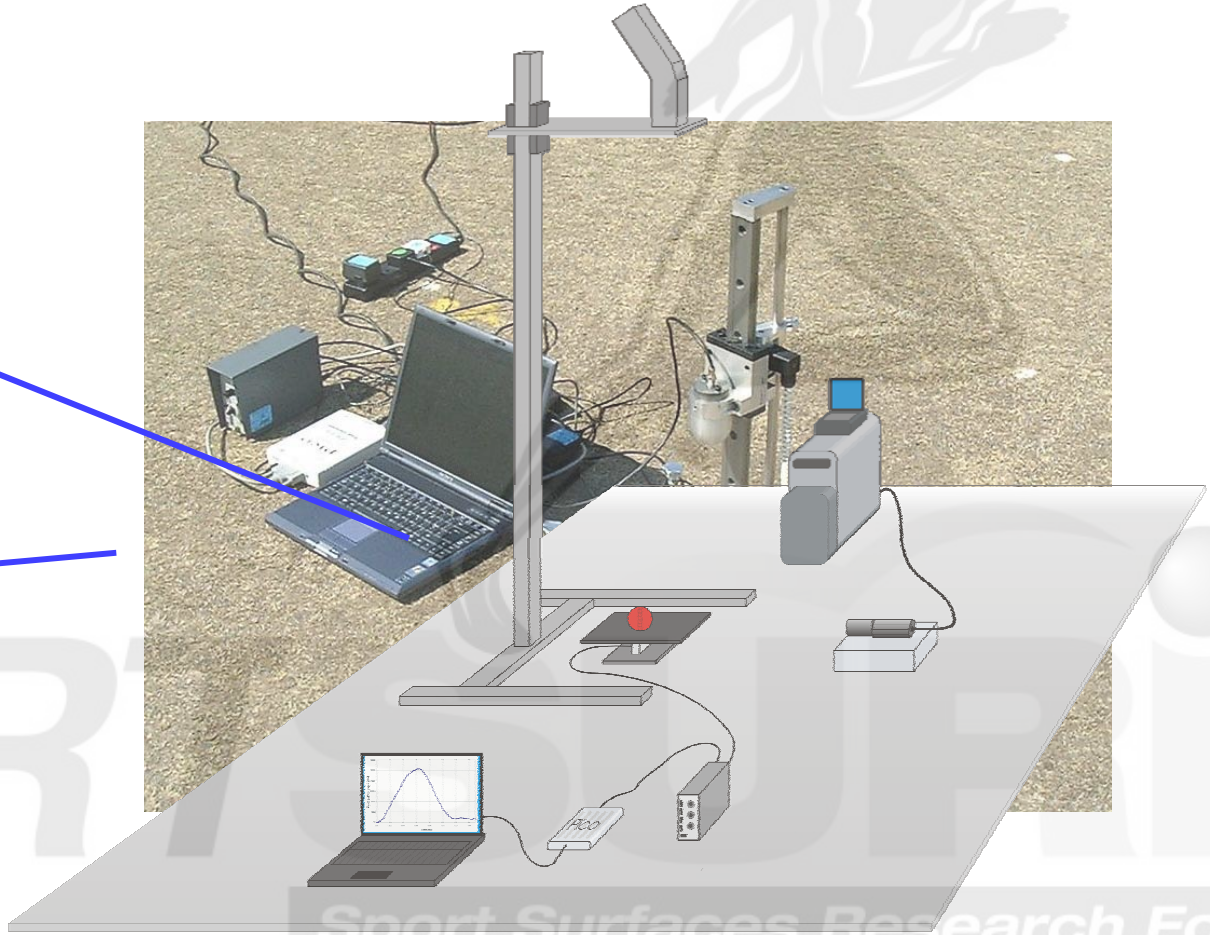
$$(F)_t = m(\ddot{y}_b)_t$$

$$(F)_t = (k_b)_{t-\Delta t}(y_b - y_p)_t + (c_b)_{t-\Delta t}(\dot{y}_b - \dot{y}_p)_t$$

$$(F)_t = (k_p)_{t-\Delta t}(y_p)_t + (c_p)_{t-\Delta t}(\dot{y}_p)_t$$

Determining model parameters…





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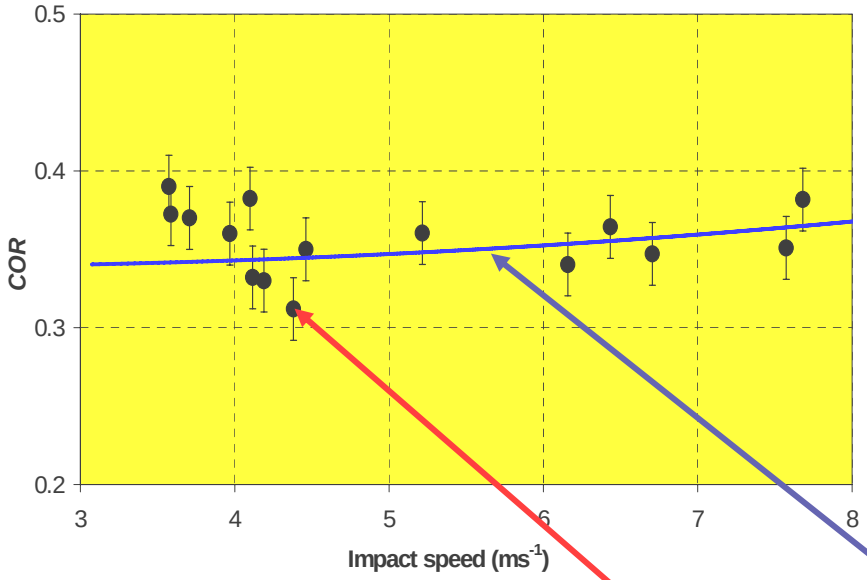
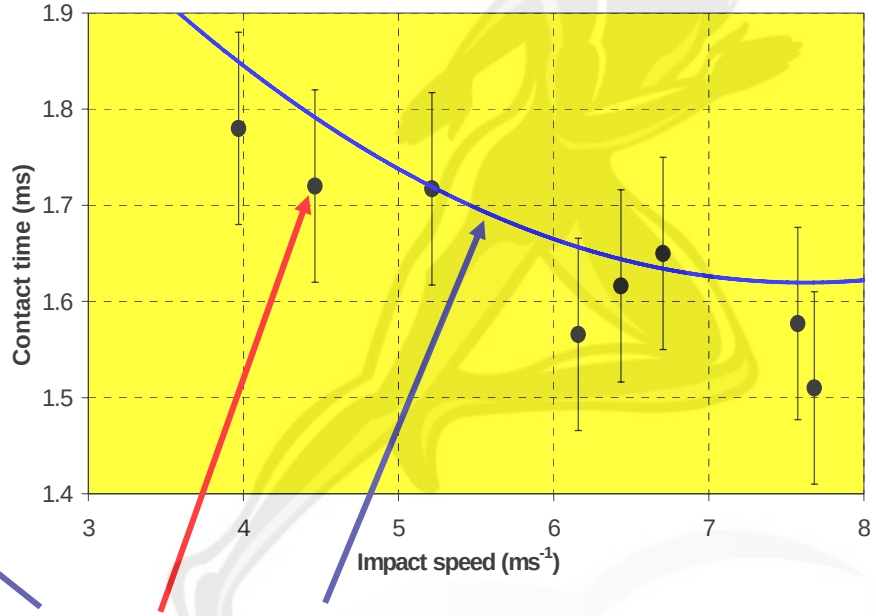
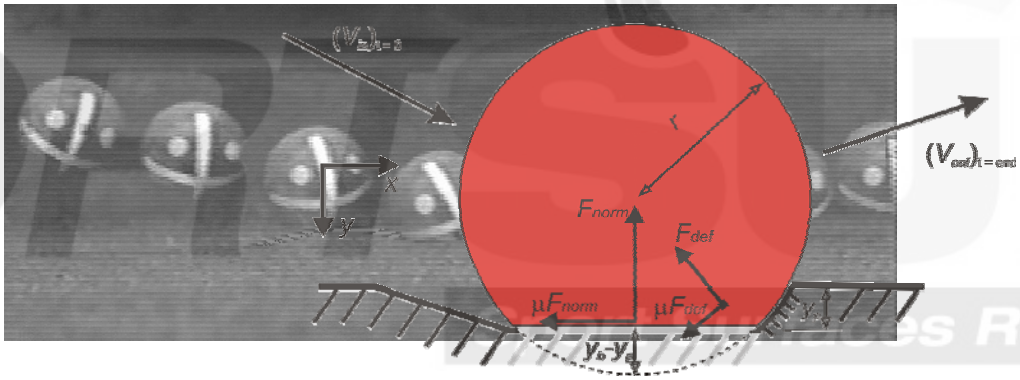
Model verification…







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FE models (Computer Simulations)…

- Used effectively in tennis
  - Surface treated as rigid
  - Applies friction
  - Very complicated for most surfaces

In Summary…

- Athlete / Ball interaction with surfaces
  - Can be assessed
  - Can be modelled (for some situations)
- The challenge…
  - To use this knowledge to improve surfaces
    - By improving collaboration
  - To fill in *gaps* of knowledge
  - For example…
    - surface consistency
    - effect of construction…

Acknowledgements…

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